Increase of Salt in Soil and Streams following the Destruction of the Native Vegetation, by **W. E. Wood**, Inspecting Engineer, Railway Department.

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For many years I have been interested in the fact that in certain districts in the southern portion of Australia where destruction of the native vegetation has taken place rapidly, there has followed a very noticeable increase in salinity in the streams draining that area.

I first noticed this over 30 years ago in Yorke's Peninsula, South Australia. Watercourses were rare but there were many depressions where soakage from higher ground gathered during the winter. In some of these depressions, gardens and orchards were planted with good results for a while, but in a few years, owing to a great increase of salt in the soil, many of them became quite useless and had to be abandoned.

Again, some years later, about 1897, in the Northam-Toodyay district, I heard it suggested that destruction of the native vegetation turned the water in the creeks salt; and about 1904 I thought that I could see evidence of increase of salinity in the Goomalling Agricultural Area.

By 1905 a number of Railway water supplies had become too salt for economical use in boilers, and various officers of the Department, particularly Mr. Bleazby, Civil Engineer, and Mr. Limb, Analyst and Chemist, gave a lot of time and thought to the problem.

Their first investigation of note was at Cranbrook, on the Great Southern Railway, long. 117° 35′ E., lat. 34° 17′ S. This supply was constructed about 1898 and consisted of an excavated tank supplied by drains from a catchment the centre of which was about two miles distant. During the early years of its life the catchment was all, or nearly all, unimproved land; but in later years the southern side of the area was ringbarked and, later on, cultivated.

About 14 years after construction the water began to get noticeably salt and to give trouble in locomotive boilers. By December, 1904, the salt-content had reached 63.5 grs. per gallon. In 1908 the catchment was tested to find the source of the bad water, and it was located on the southern side where cultivation had been in progress for a few years at that date. On the southern side of the catchment the salts in the water running in the drains in winter ranged from 30 to 73 grains per gallon; but, on the northern side, the drains which collected water from unimproved land, supplied water to the dam with a salt-content of about 7 grs. only. New cut-off drains were then constructed to divert the southern drainage from the dam, excepting when the flow was very strong, following very heavy rains. This was quite successful, and when the reservoir was filled again the salt-content was less than 7 grs. per. gallon. It has remained good since that time, and about four years ago a second tank was constructed alongside the first and the salt difficulties appear to be overcome.

Another reservoir on the Great Southern Railway where salt trouble developed is at Yornaning, long. 117° 10′ E., lat. 32° 43′ S. This supply, also, was constructed about 1888 on the south branch of the Hotham River. Settlement progressed rapidly in this district between the years 1896 and 1904, and the water, which had been particularly good in the early years of the supply increased in salt-content to 60 grs. per gallon in 1909—21 years after the reservoir was built. In May, 1910, it had reached 94 grs., and it was found on investigation that the Hotham was salt for several miles above this place. Fortunately, it was found also that two small creeks feeding the river nearby were still good; so the river water was diverted from the reservoir and the two creeks relied on to supply sufficient for railway requirements, the catchments of these creeks being acquired and the timber growing thereon protected from destruction. The result was quite successful. Following is a record of the salinity of the reservoir from 1910 to 1918:—

August 29,	1910	3·28	grs. per gallon.
November 11,	1911	16·38	,, ,,
August 5,	1913	4·1	,, ,,
March 1,	1916	6·97	,, ,,
August 28,	1916	5·33	,, ,,
March 3,	1917	9·02	,, ,,
August 31,	1917	4·1	,, ,,
February 25,	1918	4·92	,, ,,
August 28,	1918	4·1	,, ,,

Other supplies on the Great Southern Railway that were satisfactory for a time, but deteriorated in later years, following the opening up for settlement and cultivation of the areas drained are—Wagin (since corrected to a large extent by diverting the run-off from light rainfalls and the water that soaks out of the ground after the heavy rains have stopped) and Tambellup, where the supply from Gordon River had to be abandoned, as the salt water could not be economically diverted.

Another noteworthy example of a large stream becoming salt is the Blackwood River at Bridgetown, long. 116° 8′ E., lat. 33° 55′ S. I have not been able to trace its salt-content before 1904, although it had been in use for railway boilers for about seven years at that date.

The following records of tests have been kindly supplied by Mr. Limb; and, to those people who know the history of the agricultural developments in the Arthur River District—the water from the Arthur River joins the Blackwood River above Bridgetown—it will be easily recognised how the increase of salt has followed within a very few years upon the rapid extension of cultivated land in the agricultural portion of the catchment.

BLACKWOOD RIVER RAILWAY SUPPLY, BRIDGETOWN.

Date.	Salt.	Total Solids.	Hardness.		Remarks.
			Total.	Temporary.	
	Grs. per gallon.	Grs. per gallon.	Grs. per gallon.	Grs. per gallon.	
January 26, 1904 ...	10·95	18·94	7·0	...	First test of supply.
October 27, 1908 ...	19·00	32·9	9·4	2·6	
December 28, 1910	26·01	45·84	14·05	6·95	
March 10, 1911 ...	38·1	58·35	20·4	11·00	
May 30, 1911 ...	54·9	80·00	21·17	9·6	
July 20, 1911 ...	73·8	105·00	27·3	9·2	
August 18, 1911 ...	63·96	83·00	15·4	3·85	
September, 1911 ...	56·17	77·00	17·32	7·87	
December 12, 1911...	84·05	105·00	23·9	6·4	
April 22, 1912 ...	100·00	130·00	25·3	10·1	1912 rains below normal.
July 18, 1912 ...	105·78	120·00	26·77	8·57	
September 2, 1912 ...	84·46	98·00	21·00	8·05	
December 23, 1912...	76·26	90·00	21·7	6·12	
July 31, 1913 ...	35·2	45·00	11·9	2·45	
August 16, 1913 ...	9·02	12·00	2·27	1·57	Probable heavy fall of rain.
November 17, 1913	36·9	46·00	14·17	5·25	1914 rainfall much below the average.
January 10, 1914 ...	46·74	63·00	18·2	6·6	
April 24, 1914 ...	68·06	72·00	23·97	9·02	
September 10, 1914	88·1	105·00	25·0	7·1	
October 19, 1914 ...	103·3	120·00	29·22	6·82	
February, 1915 ...	94·3	115·00	28·87	8·57	
August 20, 1915 ...	80·7	95·00	25·9	2·97	
November 26, 1915	53·3	65·00	15·75	4·72	
September 18, 1916	37·31	50·00	10·76	3·58	
March 30, 1917 ...	70·52	90·00	23·62	7·87	
September, 1917 ...	21·32	26·00	5·42	2·8	After winter of record heavy rain. Supply now abandoned for new supply.

In 1913 I spent a few months on water-supply surveys in the South-Western District and soon became convinced that a number of small watercourses that had contained fresh water a few years earlier were becoming salt; and that quite an appreciable amount of rich valley land along the edges of some of the streams was also being ruined by the salt deposited when the water dried up.

In 1916 I was given a further period on somewhat similar work and continued at it for five years. During that time I investigated many locomotive boiler supplies that had become too salt for further use, or threatened to become so soon. I took the opportunity to revisit Formby, long. 118° E., lat. 34° S., where there was a small dam across a creek about one-quarter of a mile below the siding. This had shown strong evidence of increasing salinity when I was there in 1913. I had been told that the water was perfectly fresh in 1911 and 1912 when the railway was being constructed, and in August, 1913, it contained water having 40 grs. of salt per gallon. When I next tested it in November, 1916, the dam was full, but the salt had increased to about 2,000 grs. per gallon. It was said that the catchment had been cleared of nearly all native vegetation very quickly between the years of 1909 and 1913, and the new growth of saline vegetation growing in the creek and on the low-lying ground nearby was noticed by me in 1913.

It seems fairly safe to state that nearly all the districts on the inland side of the Darling Range, and lying close thereto, show some evidence of somewhat similar happenings where the native vegetation is destroyed in large quantity. The same thing applies to a certain extent in other districts where there is a good winter rainfall, but in the Darling Range, and on the upper reaches of most of the streams entering the Indian Ocean in the South-Western District, the destruction of timber and shrubs has not reached the extent that it has in the purely agricultural districts, and possibly can be prevented if large areas are protected in time.

There are now very few rivers, crossed by the railway, that contain water fresh enough at all seasons of the year to be classed as good boiler water. Water is still used from the Murray River at Pinjarra, and the Preston River at Boyanup and Donnybrook; but the increase of salt is becoming noticeable, although the pencentage of the area drained by these rivers and upon which the native vegetation has been destroyed is not great. Probably, if the destrction proceeds unchecked these streams also will have to be abandoned as sources of boiler water.

The Murray River water at Pinjarra, long. 115° 59′ E., lat. 32° 30′ S., is always worst just after the first rains, which, if heavy and continuous, ultimately reduce the salt-content to 20-30 grs.; if the rains are light the process is a slow one. This year the analyses, March to July, were as follows:—

14–3–23	...	29·5	grs. of salt per gallon.	
18–6–23	...	96	,,	,, ,,
25–6–23	...	40	,,	,, ,,
2–7–23	...	20·5	,,	,, ,,
9–7–23	...	19·7	,,	,, ,,

Although it is generally recognised that our streams increase in salinity after the native vegetation has been destroyed, I am not aware that anyone has explained the increase of salinity or the origin of the salt which causes the salinity, and I submit the following theory for discussion:—

Over a very large portion of the South-West District, more particularly that area comprised in the Darling Ranges and the wandoo, jamwood, and white gum country immediately adjacent thereto, a typical section of the ground from the surface down to the underlying rock could be described approximately as follows:—

(a) Sandy soil.

(b) Sandy clay.

(c) Very dense clay and sand cemented together, and nearly impervious. This is commonly named "hard-pan."

(d) Softer ground—often thoroughly decomposed rock *in situ.*

(e) Partly decomposed rock merging into solid rock below.

Before the native bush is destroyed, the ground is covered with vegetation, composed of large timber, of smaller and larger shrubs and of wild grasses, all growing together. All have their roots in (a) and to a less extent in (b); a few penetrate a short distance into (c). The main roots of the large trees pass through (c), and in (d) find moisture to carry the trees through the long dry summer without wilting.

While the bush remains in its virgin state, or nearly so, rain falling on the catchment area is partly absorbed by the soft layer (a), and, if the rain is long continued, some soaks into layer (b).

If the rain is very heavy, a lot runs off along the surface to the nearest watercourse to be borne rapidly towards the sea. The water that enters (a) is held by the network of small roots, and as much as is required is absorbed and stored by the vegetation. Some of the water enters (c), chiefly by following down the tap-roots of dead and decaying trees, and this is the water usually found when sinking wells; it is stored between the two almost impervious layers (c) and (e).

It is of special importance, for further consideration of the subject, that the difference of quality of water in the upper layers (a) and (b) and that in (d) be noted here. Before interference with the native vegetation the upper water is almost as fresh as rain, but in layer (d) it usually ranges from brackish to salt—in many cases too salt for stock.

The accompanying diagram shows a typical hillside section:—

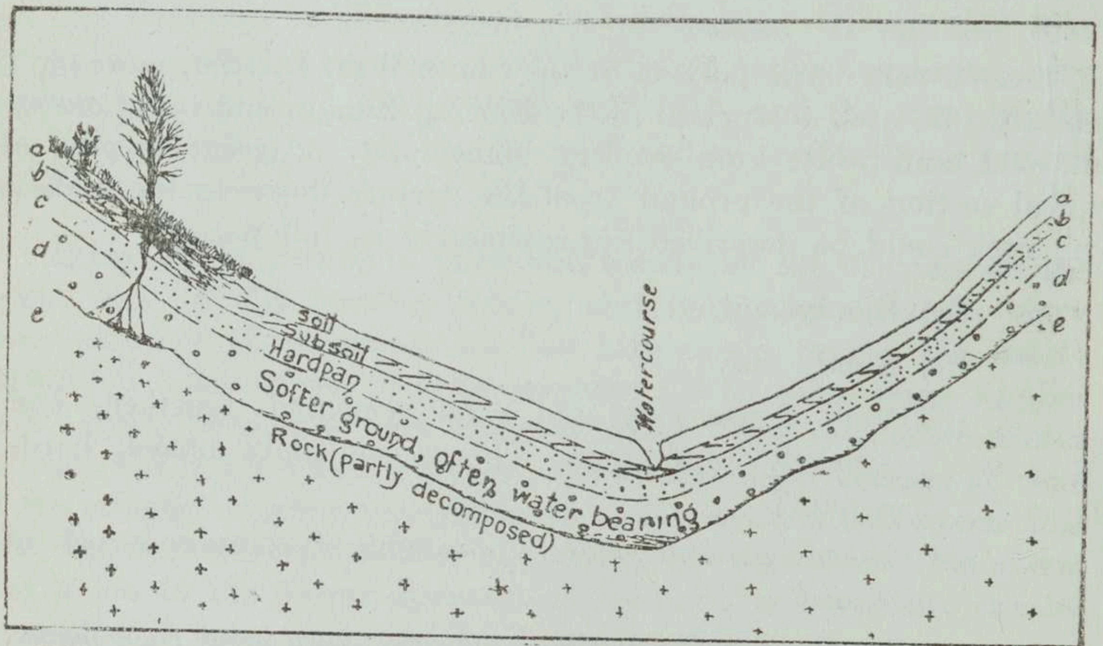

Fig. 1.—Typical cross-section of a valley. A taproot has penetrated the "hardpan" to obtain water.

It is evident that the layer (d) containing brackish water is, where on the hillside, higher than the ground surface near the watercourse. If anything happens to swell the volume of water in layer (d) on the hillside it will tend to raise the water-table in (d) near the watercourse. My suggestion is that the killing of large timber on the hillsides, followed by decay of the roots, permits more water to enter (d) than formerly. Moreover, if the surface is cultivated, the soil acts as a sponge to hold more water, which in turn drains into the underground channel (d). It can be assumed then that more water will drain into (d) than can percolate away to the coast without raising the water-table. As a consequence of this, water will, if increased greatly, rise to the semi-impervious layer (c), and if that has also been rendered pervious by decayed root holes near the watercourse, the underground water will rise through it, and perhaps to the surface, bringing its salts with it. When the rainy season is over the water will gradually dry up, leaving evidence of its salinity on the surface in a salty incrustation on the low-lying ground.

More than one explanation of the greater salinity of water in layer (d) than in the upper layers has been advanced. It has been suggested that the decomposition of the country rock has released the salts; but these salts are mainly chlorides, and, so far as I have been able to ascertain, there is not sufficient chlorine in the rocks to account for the salts in the water. Neither is there evidence of saline beds such as might be expected if the sea had been over the land in recent geological times, and, when receding, had left salt stored in the upper layers of the soil. In any case this explanation does not seem satisfactory, for rinsing by rain-water, continued for the long time during which this part of the State has remained under the same physiographic conditions, would have washed nearly all the salt out of the higher levels and concentrated it lower down if it had not carried it away to sea. But I have found places where the concentration was greater at the higher levels than at the lower. One of these is a few miles from Narrogin, about long. 117° 15′ E., lat. 33° S. At this place a ridge runs eastward from the Darling Range, and forms portion of the divide between the Avon, the Hotham, and the Arthur Rivers. The ridge is nearly denuded of indigenous vegetation now, and the creeks flow strongly from near the summit in winter. I tested many of the streams in August, 1919, and found not one of them suitable for water supply purposes, owing to their high salt-content; but although they range from 46 to over 400 grs. in the upper levels, they were markedly fresher two or three miles lower down, where 25 grs. appeared to be the average.

The occurrence near Narrogin, coupled with another near Albany, seemed to me to support a theory I had formed some years previously that, most of the salt, at least in the South-Western Division of Western Australia, is air-borne, and that salt is still being brought in from the sea in material quantity, and is either deposited in rain, or as a dry powder, or in dew, chiefly in summer.

The salt would be derived from very fine spray formed by the strong breezes which lash the tops of the waves into spindrift at any season of the year; but in summer, usually under a cloudless sky, the spray would evaporate quickly and the fine residue of salt would remain in suspension while the wind continued strong. The outline of the particle of salt would probably be irregular, with a very large surface compared to its actual weight, and it is not hard to imagine the transportation of such particles for a long distance under the described circumstances.

These winds blow for hours, usually starting about noon of most days in summer, from the West and South-West, and travelling far inland before they fade and lose their strength. They are known locally as the Fremantle, Dongarra, Albany, Esperance, etc., "Doctors," according to the part of the coast whence they come.

So far as the salt in rain is concerned, it is not so very exceptional to find 3 grs. of salt per gallon in rain falling on the western slopes of the Darling Range, and during a very strong gale, that had lasted four days, at the end of June, 1917, I tested rain and hail at Donnybrook, long. 115° 40′ E., lat. 33° 38′ S., distant about 20 miles from the Indian Ocean, and found them to contain 8 grs. of alkaline chloride. The salt-content was only 4 grs. in rain that fell about two hours later. I had hoped to go further into the matter with Mr. Curlewis, of the Meteorological Bureau, and Mr. Limb, the Railway Department's Analyst, but so far neither time nor funds has been available.

As further evidence of the amount of salt borne inland yearly, I would mention an occurrence at Mullewa this year. Mullewa is situated near the north end of the South-Western Division of Western Australia in long. 115° 30′ E., lat. 218° 30′ S. It is about 60 miles from the coast, and there are two railway tank dams there for locomotive purposes, one dam lined with concrete, the other unlined. It was a very dry season last year, and no water entered the dams from the first week in August, 1922, to the second in March, 1923. The catchments join near the town and the dams are about half a mile apart. The catchment of the unlined dam was kept free from stock, being fenced, and is covered almost completely with green timber. The surface is very impervious, being chiefly hard clay and, in some places, a very hard rock, whose original character has been much altered by the processes of weathering characteristic of these regions. There is very little soft ground for water to soak into readily. The catchment for the lined dam is somewhat similar but is subject to pollution by wandering stock and people living on it. In March of this year a local thunderstorm crossed the catchment of the unlined dam and put about 200,000 gallons of water into the dam, which is sunk in hard clay and decomposed rock (probably granite). The water was tested and found to contain 180 grs. of salt per gallon. As the normal salt-content of both dams is about 7 grs., I had water from the masonry silt pit tested, in case the excessive salt was a soakage into the unlined dam. The silt pit water contained 176 grs. This water was then all pumped to waste.

As the storm had not set water running on the other catchment, water from the lined dam could not be tested, but I made arrangements to get tests of water from both catchments should there be a suitable rain, and, a few weeks later, a good thunderstorm passed over and put water in both dams. 600,000 gallons were impounded in the lined dam, which had not benefited by the previous rain, and the salt-content was 33½ grs. per gallon and 19.68 grs. in the silt pit of that dam, but in the silt pit of the dam of the previously washed catchment the salt was only 2.87 grs. per gallon, thus a considerable salt-content was obtained from the catchment which had not been washed by the previous rain, and a small salt-content from the one which had. There are no salt lakes of large extent near Mullewa and most of the country is still covered with green timber of small size.

If the Mullewa records can be accepted as evidence of a salt film of material thickness being deposited over the South-Western District of Western Australia during the summer months, they will assist in explaining the phenomena of salinity in the Murray River at Pinjarra, over 300 miles farther south, where it is found (*see* table on a previous page) that the river water is salter after the first rains following the dry season than during the height of the dry season.

DISCUSSION.

Mr. A. Montgomery congratulated Mr. Wood on the number of very valuable records of instances of increased salinity which had come within his personal professional experience. His suggestion that the death and decay of large roots which penetrate the subsoil deeply, facilitated the passage of surface waters through the hardpan seemed particularly worthy of attention, and the inference that the water-table would be raised in the lower-lying ground seemed sound. The manifest remedy for salinification of low-lying ground lay in good drainage, which would drain off the rising saline waters well below the surface of the ground and not allow them to rise high enough to injure the crops.

The subject dealt with by Mr. Wood had an important bearing on the physiography and recent geological history of the State. He (Mr. Montgomery) had paid a good deal of attention to the subject and had (Jour. Roy. Soc. W.A., Vol. II., p. 59) ascribed the excessive and widespread salinity of the part of the State lying south of about lat. 29° S. to a recent submergence followed by elevation into its present position.

Regarding Mr. Wood's opinion that soil salinity is due to particles of salt borne by the wind from the surface of the sea, the presence of salt in atmospheric dust and in rain and dew is recognised, but the amount borne inland must, he thought, be similar all over the world, for clouds formed by condensation of vapour from the sea are often borne far inland, and doubtless the fine saline dust can be carried just as far by the same air currents. Hence all arid regions should accumulate sea-salt in their soils, for none are beyond the reach of winds circulating both over land and sea. However, there are many arid regions in which salts other than sodium chloride predominate. Even in Australia the occurrence of saline areas is distinctly regional and not universal.

It was to be noted that the amount of saline matter in the air has not necessarily any relation to the amount of water evaporated, since the salt-dust in the air is derived from particles of spray carried by wind into the air and there evaporated. Most of the spray falls back into the sea, and only a small percentage is evaporated and contributes salt-dust which may be carried inland by the wind.

Mr. Montgomery considered that wind-action on the saline surfaces of the many salt "lakes" of Western Australia must contribute very largely to salt-dust in the air, which must be constantly falling and forming a layer on the surface of the ground which would dissolve when the first shower of rain fell on it. He would ascribe to such terrigenous salt-dust the sudden iscrease in salinity of the Mullewa dams described by Mr. Wood.

Mr. Montgomery stated that numerous wells throughout the more saline districts show that fresh water is near the surface, and that, if the well is deepened, we reach first brackish then salt water. He thought there could be no doubt that this is due to the rainfall being fresh water, which sinks into the soil and forms a layer of lighter fresh water upon the heavier saline waters accumulated below. In such circumstances the mixture of the fresh and salt water would progress very slowly. A well known case was that of wells near the seashore, where rain-water sinks through sand and accumulates in a subsoil pool, displacing the salt water, a higher column of the lighter fresh water balancing a lower one of the heavier salt water. He considered that our Goldfields "soaks" near granite rocks are another instance of the same action.

The salinification of cultivated lands on removal of the native vegetation he believed most probably to be due to quicker evaporation from the bared soil. When the cover of natural vegetation and the shade of trees are removed, evaporation is much more rapid, and capillary attraction brings up through the soil the more saline waters lying below the surface, causing a concentration of salt from these by evaporation.

That the salt is in the soil and emanating from it, and not being brought down from atmospheric salt-dust, seemed to him to be fairly well proved by the experience of the Mundaring dam, where it is necessary from time to time to run out to waste a quantity of somewhat salt water from the bottom of the dam, where it accumulates. The salt water once thoroughly mixed with fresh cannot separate again, and the salt water layer on the bottom must, in his opinion, come from the earth below the dam and not from the streams filling it. Doubtless this saline accumulation would disappear in course of time.

Dr. E. S. Simpson congratulated Mr. Wood on the assemblage of observations, extending over many years, which he had put together. He agreed that the salts the author dealt with had not come from the weathering of the rocks, if they had, then carbonates and sulphates would predominate. He thought that in this, as in many other phenomena, several causes had contributed to the final result. He had watched at Yallingup the drifting inland of mists composed of finely comminuted spray from the sea, and noticed the strong salinity of ground waters within a mile or two of the shore in that neighbourhood, but one only had to go four or five miles inland to find fresh ground-waters. Thus, he considered, that the wind-borne salt was not adequate to account for the widespread occurrence, south of about lat. 20°. S., of saline ground-water in the interior of the State. Determinations of air-borne ocean salts made some years ago in Cumberland pointed in the same direction. He believed that the salt water was oceanic in origin and dated from the Cainozoic submergence of the southern part of the State. He thought Mr. Wood's explanation of increase of salinity was sound, but drew attention to some other contributory factors, namely, the inevitable increase in salinity which must take place, under the climatic conditions obtaining in Western Australia, in every dam which is not regularly and completely emptied; the increase in surface salinity which must follow on the removal of vegetation which by its root-absorption would check the upward capillary movement of the deeper water with its dissolved salts; and the fact that in seasons of excessive rainfall far inland the west-flowing rivers of the South-West Division receive some overflow water from the lakes (salinas) of the inland area, the sub-surface water of which is saturated with salt, gypsum, magnesium sulphate, and magnesium chloride.

Mr. J. M. Limb, Chemist to the Railway Department, was invited by the President to contribute to the discussion, and remarked that there was a great accumulation of data in possession of the Railway Department, which, if properly arranged, might throw considerable light on the subject under review. He gave instances of the variation of salinity of a number of water supplies which he had personally investigated; those specially mentioned being at Cranbrook, Yornaning and Wagin. In each instance it had been proved that the variation in salinity was not due to any fault in the dam, but to contamination from some part of the watershed.

In the case of the two first-mentioned, the contaminated waters could be diverted, but in the case of Wagin, where the source of contamination was in the centre of the catchment, and could not be isolated, the permanent low wall weir was the only method of obtaining suitable water after heavy rains.

He had found by experience that small reservoirs could not be well compared with very large ones, and that Mr. Montgomery's contention regarding the high salinity of the bottom layers in Mundaring water was not supported by the evidence in his possession. He had found that where the main intake of a reservoir was far removed from the wall, there was only slow diffusion, and data appeared to indicate that at Mundaring the more saline water following the lighter rains did not reach the wall until the subsequent heavy rainy season. This was evidenced by sharp increase in salinity prior to very considerable and rapid improvement. The following figures would demonstrate the point.

		Salt in grains pr gallon.
1915	May average ...	30·2
	June average ...	30·2
	July average ...	32·4
	August 4th ...	31·15
	August 5th ...	29·5
	August 6th ...	27·0
	August 9th ...	26·0
	August 12th ...	12·3
	August 13th ...	10·6
1917	May average ...	22·4
	June 12th	22·9
	June 22nd	24·2
	June 26th	24·6
	June 27th	13·8
	June 28th	11·5
	July 25th	7·8

It had further been found that when the sluice was open, the water in the creek was almost identical with the water supplied by means of the various mains, and improved at the same time as the water in the mains improved when better water reached the wall.

Confirmation of this was also found in the Chidlows reservoir water supply, which contains 117 million gallons. The depth of water at the wall being 29 feet. Even when the rains were light and the streams very saline, the difference between top and bottom water had never exceeded 2.0 grains per gallon at the wall. He felt that the subject was such that it was impossible to cover the field adequately or consider fully the data available in the time allotted.

Mr. W. Catton Grasby congratulated Mr. Wood on having made a notable contribution to a difficult and very interesting problem. He thought, however, that there was not much passage of water from the surface through the hardpans, and, where the section applied, this water did not again pass upward through the hardpan in order to reach the surface on lower ground. He (Mr. Grasby) considered that the saline water which caused gullies to become salt was carried through the soil and subsoil by the winter rains and was carried down the slopes over the hardpan. He further noted that Mr. Wood's diagrammatic section did not represent the conditions of the best forest land in the wheat belt, although it certainly was typical of the localities of the railway tanks referred to.

The best wheat lands were more or less wide, almost flat stretches of country separated by higher undulating moor or heath and scrub lands, commonly but wrongly called "sandplain." The valleys were covered with forests, chiefly Salmon Gum (*Eucalyptus salmonophloia*), Morrell (*E. longicornis*), Gimlet (*E. salubris*), and York Gum (*E. loxophleba*).

Fresh water soaks and shallow wells were often found on the borders of the moorlands or "sandplains," but in the richer, deeper, "made" soil of the timber country, while it was in many places easy to get water in wells, it was almost invariably salt.

Mr. Wood, in reply, remarked that his paper dealt only with the South-Western District, more particularly the Darling Range and the country immediately adjacent to it, and he hardly expected, as Dr. Simpson and Mr. Montgomery seemed to think he did, that his conclusions would be equally applicable to every part of the State. Still, he believed that the boundary between that part of the State in which ground-water was salt and that in which it was potable, corresponded approximately to the boundary between areas of winter and of summer rainfall, and that all the country alike became covered during dry weather with a skin of wind-borne salt particles. In the areas of summer thunderstorms, however, the torrential rain washed the salt down into the watercourses, so preventing its accumulation in the soil. He referred to the occurrences at Mullewa, already detailed, as supporting this view.

By Authority: FRED. WM. SIMPSON, Government Printer, Perth.